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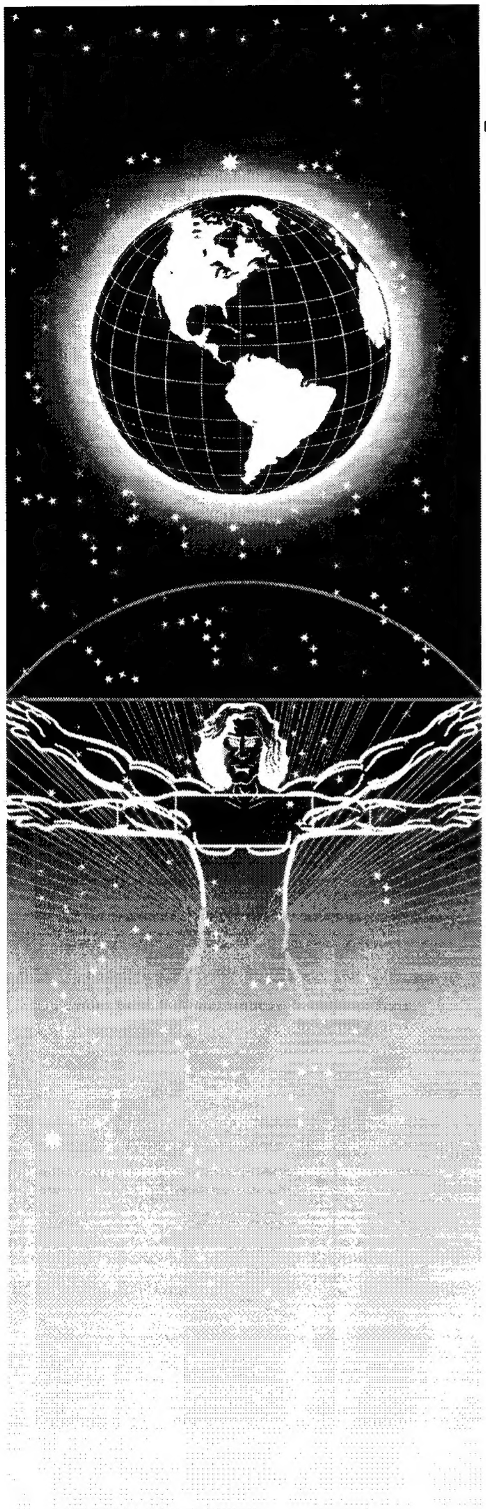

UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

F-16 MULTITASK TRAINER/ WEAPON SYSTEM TRAINER ENTITY LIMIT UPGRADE

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In preparation for a research effort entitled, "Multi-Distributed Training Testbed, Air-to-Air," or MDT2 Air-to-Air, which had a requirement to handle up to 14 independent, dynamic aircraft entities, it was brought to light that the existing Weapons Systems Trainers (WSTs) in use at the Aircrew Training Research Division of Armstrong Laboratory's Human Resources Directorate (AL/HRA) had real-time limitation of only five dynamic, independent aircraft. The reason for this was that Operational Flight Trainers (OFTs) had the five-target limit and the WST code (which was the same as the Air Force Reserve Multitask Trainer [MTT] code) based on the OFT legacy code. The purpose of this technical effort was to modify the F-16 WST software to enable the WST to handle up to 25 independent, dynamic aircraft generated in a Distributed Interactive Simulation (DIS) network and handed to the host through a network interface unit.

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Air entities; Aircraft; Exercises; F-16; Flight simulation; Flight simulators; Flight trainers; MTT; Multitask Trainer; OFT; Operational Flight Trainer; Target; Weapon System Trainer; WST;

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PREFACE

This work was conducted by Hughes Training, Inc., Training Operations (HTI) under a contract with Armstrong Laboratory, Human Resources Directorate, Aircrew Training Research Division (AL/HRA), located at Williams Gateway Airport in Mesa, Arizona.

The effort was performed under AL/HRA Contract Number F41624-95-C-5011 and Work Unit Number 2743-25-06, Aircrew Training Research Support. The laboratory contract monitor was Mr Daniel Mudd; the laboratory technical monitor and principal investigator was Dr Herbert H. Bell.

F-16 MULTITASK TRAINER/WEAPON SYSTEM TRAINER ENTITY LIMIT UPGRADE

INTRODUCTION AND BACKGROUND

The F-16 Weapon System Trainer (WST) software, which is based upon the legacy F-16 Operational Flight Trainer (OFT) software code, required modification in order to increase the maximum number of network-generated entities that could be processed by the WST radar, radar warning receiver (RWR) and Missiles. The desired goal was to process up to 25 dynamic, six-degrees-of-freedom moving models. The existing F-16 OFT software in training systems currently fielded throughout the Air Force (including the AFRes Multitask Trainers [MTTs]) was developed for stand-alone training applications with all targets being generated internally on the host hardware. The OFT/MTT software is currently capable of processing and displaying only five independent, dynamic aircraft. As a matter of information, the words "target and aircraft" will be used throughout this technical paper interchangeably to imply both red and/or blue aircraft. It was confirmed during the course of this upgrade that another friendly aircraft counted as one of the five entities placed in the target list.

This technical effort was limited to modifying internal WST host software matrices and parametrics in a way that allowed the host to handle many more targets generated externally on the Distributed Interactive Simulation (DIS) network and processed through a Network Interface Unit (NIU). It was not the purpose of the effort to actually modify the existing legacy code. Therefore, this process did not increase the number of independent targets that can be generated internally. That limit still exists in the fielded OFT and MTT simulators. When the entity limit was increased, some significant central processing unit (CPU) processing limitations were revealed, particularly on the CPU handling the Network and Visual interfaces (C9). As a result of C9 beginning to time-out repeatedly, data to C8, which handled missile fly-outs, became unstable and weapons effectiveness was affected. This shortfall in processing power in C9 resulted in the addition of an MVME-187 board to each WST cockpit. The tasks running on processor C9 were split between the existing C9 and a new CPU designated C10. Although the resulting configuration was sufficient to run the air-to-air scenarios required by the Multi-Distributed Training Testbed (MDT2) Air-to-Air Project with Patuxent River, Maryland, which was 12-14 air targets (red and blue), the existing processing capabilities using the existing hardware platforms were not sufficient to process the full 25 targets allowed by the software modifications.

EXISTING CAPABILITY

The existing OFT/MTT software, while not allowing more than five independent aircraft, had the ability to attach followers (fixed wingmen) to one or two of these five independent aircraft. It was designed to allow up to ten followers to be attached to the two independent aircraft for a total of 25 aircraft. Therefore, the radar and missile code could already lock on and shoot at up to 25 targets, but 20 of those targets were fixed to the two lead aircraft. Much of the information required by the radar and missiles was provided by the lead aircraft. In order to

process 25 independent targets, ties to the lead aircraft needed to be removed and replaced with the actual target information. Figure 1 is a generic illustration of how the existing code processed the 25 targets. This example shows how the code calculates ownship to target range rate. For targets 5 through 25, the code indicates that some target information uses data from the lead aircraft, while the balance of the data is taken from and stored in the actual target arrays.

```
for ( tgt_index = 0; tgt_index < 25; tgt_index++)
{

   if (jtact[tgt_index])
   {

      temp_index = tgt_index;

      if (tgt_index > 5   && tgt_index <= 15)
         temp_index = *jlead1;  /* *jlead1 - INDEX OF LEAD FOR TGT 5-15 */

      if (tgt_index > 15)
         temp_index = *jlead2;  /* *jlead2 - INDEX OF LEAD FOR TGT 16-25 */

      /* FOR TGTS 5 - 25, THE FOLLOWING CALCULATIONS USE THE VEL.  */
      /* (jxdot,jydot,jzdot) OF THE LEAD TGT.  FOR TGTS 5-15, *jlead1 HOLDS */
      /* INDEX OF THE LEAD TGT.  FOR TGTS 16 - 25, *jlead2 HOLDS THE     */
      /* INDEX OF THE LEAD.  THE VARIABLES jxtfe,jytfe, and jztfe USE THE */
      /* ACTUAL INDEX OF THE TARGET (1-25).                              */

      txdotx = (jxdot[temp_index-1] - *neuet) * jxtfe[tgt_index];
      tydoty = (jydot[temp_index-1] - *nevet) * jytfe[tgt_index];
      tzdotz = (jzdot[temp_index-1] - *newe) * jztfe[tgt_index];
      jrrlos[tgt_index] = (txdotx + tydoty + tzdotz) / jrtf[tgt_index];
```

Figure 1

REQUIRED MODIFICATIONS

When modifications were made to the code for processing 25 independent network targets, it was done to preserve the existing functionality. Therefore, when the cockpit is run in network mode, it is able to process 25 independent network entities. When run in the stand-alone mode using internal targets, there can still be 5 dynamic targets and up to 20 followers. Figure 2 illustrates how the software in Figure 1 was modified to handle the 25 network targets.

```
for (  tgt_index = 0; tgt_index < 25; tgt_index++)
{

   if (jtact[tgt_index])
   {

      /* IF NETWORK TARGET (nplayr[tgt_index] IS 1), THEN USE ACTUAL */
      /* TARGET INFORMATION. IF NOT NETWORK TARGET, PROCESS   */
      /* THE SAME AS BEFORE, WITH VELOCITIES TAKEN FROM LEAD  */

      if ((tgt_index < 5) | | nplayr[tgt_index])  /* IF TGT 1-5 OR NETWORK TGT */
        temp_index = tgt_index;
      else if (tgt_index > 5   && tgt_index <= 15)
          temp_index = *jlead1;
       else if (tgt_index > 15)
          temp_index = *jlead2;

     /* IF NETWORK TARGET, ALL DATA ARE ACTUAL TARGET DATA. IF      */
     /* NOT A NETWORK TARGET, IT WILL AS BEFORE, USE VELOCITIES   */
     /* OF THE LEAD TARGET FOR TGTS 5-25.                          */
       txdotx = (jxdot[temp_index-1] - *neuet) * jxtfe[tgt_index];
       tydoty = (jydot[temp_index-1] - *nevet) * jytfe[tgt_index];
       tzdotz = (jzdot[temp_index-1] - *newe) * jztfe[tgt_index];
       jrrlos[tgt_index] = (txdotx + tydoty + tzdotz) / jrtf[tgt_index];
```

Figure 2

As previously mentioned, all dependencies to the lead aircraft were removed, and the actual target information was used for the network targets. This required that all routines be identified having dependencies to the lead aircraft. The following section lists all files that required modifications. The actual modifications were similar to the example given in previous sections.

INIT ROUTINES

u506.c

RADAR ROUTINES

r418.c
r522.c
r563.c
r784.c
r786.c

THREAT ROUTINES

j001ln.c
j005kn.c
j007kn.c
j009kn.c

WEAPON ROUTINES

a510.c
a513.c
a514.c
a563.c
a568.c

During this upgrade, it was discovered that instead of using a variable name associated with target array dimensions, any applicable arrays were dimensioned using the number "5." Therefore, when the changes were made to use actual target data rather than data from the lead target, there were several target arrays in symbol dictionary like target velocity (jxdot) which had to be found by error declarations during recompiles using the number five instead of a variable equal to five. All of these targets required identification, and their dimensions changed to 25. The following section lists all of the symbol dictionary variables that were redimensioned.

Variable	Description
jtheta	target pitch angle
jphi	target roll angle
jxdot	target velocity north
jydot	target velocity east
jzdot	target velocity down
nplayr	logical, set to 1 if tgt is network player
rxdot	used in radar: target velocity north
rydot	used in radar: target velocity east
rzdot	used in radar: target velocity down
jpsi	target true heading
jvel	target true airspeed
jthrst	target thrust (actual)

jmta	target max thrust available
jtype	target type 1=ground 2=ship 3=air
asigx	maximum target IR signature
jl1	target b matrix element al1
jl2	target b matrix element al2
jl3	target b matrix element al3
jcosth	cosine of target pitch
jsinth	sine of target pitch
jcossi	cosine of target heading
jsinssi	sine of target heading
jf16ca	F-16 angle off target nose
jsize	target size 1=small, 2=medium, 3=large
jn	target load factor (Gs)
jfrz	target freeze flag

The final area to be discussed is a problem in the real-time file downloading caused by redimensioning the arrays. On the WST and MTT simulators, when the real-time files are read into memory, they are read in segments of data that map into variables in the symbol dictionary. When the symbol dictionary variables were redimensioned, they were moved to a new partition so that the existing mapping and dependencies could be maintained. In this case, there were data for the max infrared (IR) signature, ***asigx***, which was filled in from the real-time data files. When ***asigx*** was dimensioned to 25 and moved to the new symbol dictionary partition, the IR signature information was no longer filled in. For this reason, the IR seeker of the AIM-9 did not pick up the target. The solution was to add the setting of the IR signature information in the initialization routines.

CONCLUSIONS AND RECOMMENDATIONS

The entity limit upgrade has been in place for several months, and the radar, RWR and missile systems are all working well with the increased external target capability. However, even though the software is in place to handle 25 network entities, the current hardware limitations (processing power) will not allow processing of the full 25 targets. During various studies and evaluations since this software modification, it has been determined that the system runs a 12-target scenario with no time-out problems. However, as the targets (this includes friendly wingmen or other blue resources) are increased past 12, some time-outs start to occur in critical processes. The WST simulator was flown in 14-target scenarios and was successful in locking on and killing most targets, but the existing time-outs began to cause unpredictable results. Beyond 14 targets, nearly all of the missiles began to be misses due to extreme time-out conditions in several of the CPUs in the host chassis. It is therefore recommended that in order to attain the capability to process multiple dynamic aircraft in excess of 12-14 entities in a DIS environment, systems engineering work should begin immediately to evaluate, design, test, recommend and implement new hardware solutions to the F-16 WST based upon the latest CPU technologies such as PowerPC, DEC Alpha and MIPS. In addition, concurrent efforts should be conducted to improve known and unknown software limitations to AL/HRA assets, and changes should be made available to the AFRes F-16 MTT program.

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